NATURAL RESOURCES

INACTIVE AND ABANDONED MINE LANDS— New Light and Mammoth Mines, Slate Creek Mining District, Whatcom County, Washington

by Fritz E. Wolff,
Donald T. McKay, Jr.,
and David K. Norman

WASHINGTON
DIVISION OF GEOLOGY
AND EARTH RESOURCES

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site location

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INTRODUCTION

Presently in Washington State there is no systematic database of inactive and abandoned metal mines (Norman, 2000). Previous work by the Department of Natural Resources (DNR) has had a distinctly commodity-oriented focus (Huntting, 1956; Derkey, 1990). The current goal is to build a single database and geographic information system (GIS) coverage of major mines in the state. Documentation will focus on physical characteristics and hazards (openings, structures, materials, and waste) and water-related issues (acid mine drainage and/or metals transport). Accurate location, current ownership, and land status information will be included. Acquisition of this information is a critical first step in any systematic approach to determine if remedial or reclamation activities are warranted. Open-File Reports (OFR) will provide written documentation on mines or groups of mines within specific mining districts or counties.

Over 3800 mineral properties have been located in the state during the last 100 years (Huntting, 1956). Many are undeveloped prospects of little economic importance. Therefore, in considering the population to include in the Inactive Mine Land (IAML) inventory, we have identified approximately 60 sites that meet one of the following criteria: (a) more than 2000 feet of underground development, (b) more than 10,000 tons of production, (c) location of a known mill site or smelter. This subset of sites includes only metal mines no longer in operation.

We have chosen to use the term *inactive* in the project's title in addition to the term *abandoned* because it more precisely describes the land-use situation regarding mining and avoids any political or legal implications of surrendering an interest to a property that may re-open with changes in economics, technology, or commodity importance.

Creation of the state-managed IAML database is a cooperative effort between DNR, the U.S. Forest Service (USFS), the U.S. Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (DOE). DNR's Division of Geology and Earth Resources (DGER) is the lead agency. To date, USFS contracts have been the principal source of funding, with other contributions coming from DNR and EPA.

SUMMARY

The Slate Creek Mining District (Figs. 1,2) lies at the easternmost boundary of Whatcom County, 32 miles by road from Winthrop, Wash. The New Light and Mammoth mines accounted for almost all of the district's lode gold production. The two mines are situated within a half mile of each other near the historic settlement of Barron. The original New Light workings occupied 19 unpatented claims between Allen Basin and Indiana Basin on a steep southeast-facing shoulder of Tamarack

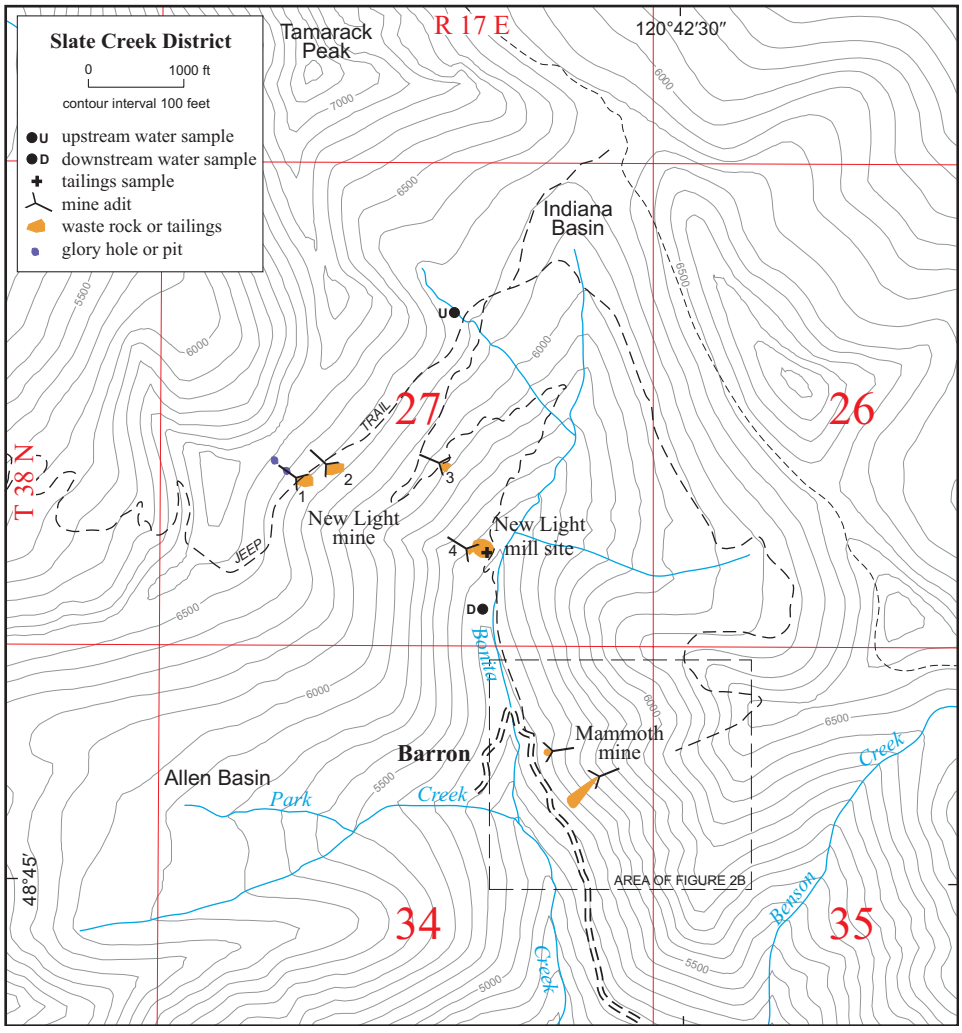

Figure 1. Site map of the New Light and Mammoth mines.

Peak. Elevations at the New Light range from 5300 to 6900 feet in portions of sec. 27, T38N R17E. The Mammoth mine is located in portions of NE¼ sec. 34 and NW¼ sec. 35, T38N R17E (Fig. 2B). Operations at both mines have been strongly influenced by the presence of snow pack nine months of the year and avalanche-prone topography.

Nomenclature surrounding the New Light mine can be confusing. It has been known as the Eureka, Bonita, Slate Creek, Monica, and Western Gold mine. These titles are more reflective of various mining companies' names, as opposed to the names of the properties. We use New Light throughout the report in accord with Moen (1969). Figure 3 shows an overview of most of the New Light workings. We collected field data during August of 2001.

Ownership

All of the lands formerly mined lie within the Wenatchee–Okanogan National Forest, which is administered by the U.S. Forest Service. As detailed below, private parties own 14 patented claims, previously held as part of the New Light mine by Western Gold Mining Co., and the Mammoth mine's original five patented claims. No unpatented claims for either mine were active in December of 2002.

History

During the years 1895 through 1935, the New Light mine was owned respectively by the Eureka Mining Co, C.D. Lane, Bonita Gold Mining Co., Brown Development Co., and New Light Gold Mining Co. During that period, two glory holes were mined yielding $350,000 in gold from enriched surface mineralization, 8000 feet of underground development was completed, and a ten-stamp mill was erected. Mining operations were sporadic. In 1935, a 50-ton flotation mill replaced the stamp mill. Western Gold Mining Co. (WGM) acquired the property in 1940, which by that year consisted of 46 claims and 13,150 feet of underground development. Government Order L-108 halted all gold mining operations within the U.S. in 1942. From 1942 to 1965, WGM increased mill capacity to 120 tons per day, conducted diamond drilling, and bulldozed a vast array of surface trenches in an effort to develop ore reserves sufficient to justify large-scale operations. About 300 tons of ore were produced during that time. Consultants hired to evaluate the exploration activity estimated ore reserves of about 1.1 million tons (Magill, 1969) and (Cheney, 1971). The property lay idle until 1979 when Lion Mines Ltd., Vancouver, B.C., obtained a lease. They mined 1000 tons of surface ore adjacent to the original glory hole and 6200 additional tons in 1980. Lion Mines' lease expired in 1983, the same year an avalanche destroyed the flotation mill and diesel electric plant. A joint venture between the U.S. Forest Service and WGM in 1984 removed the mill debris from Bonita Creek and rehabilitated the tailings pond. The last entry in DGER mine files, dated June 1986, indicates that Stray Horse Resources, Inc., entered into a 7-year lease agreement with WGM. No data on activity or production from this agreement is available.

The Mammoth mine was also discovered in 1895. A 5-stamp mill was built in 1898 on the southwest corner of the Mammoth claim. About 15,000 tons were produced from stopes above the mine's principal entry, known as the Mammoth tunnel, prior to 1901. In that year, eastern financial interests acquired control and constructed a wire-rope tramway extending from the mine to a 10-stamp water-powered mill at the confluence of Bonita Creek and Slate Creek, a distance of 3800 feet. The property lay idle until the early 1930s when D. W. McArthur bought it at a tax sale. In 1936, the Mammoth Gold Mining Co. drove an adit known as the 'D' level approximately 400 feet below the Mammoth tunnel. This work resulted in a small shipment of ore to the Tacoma smelter, which probably represents the last production from the property. United States Resources and Industries Corp.

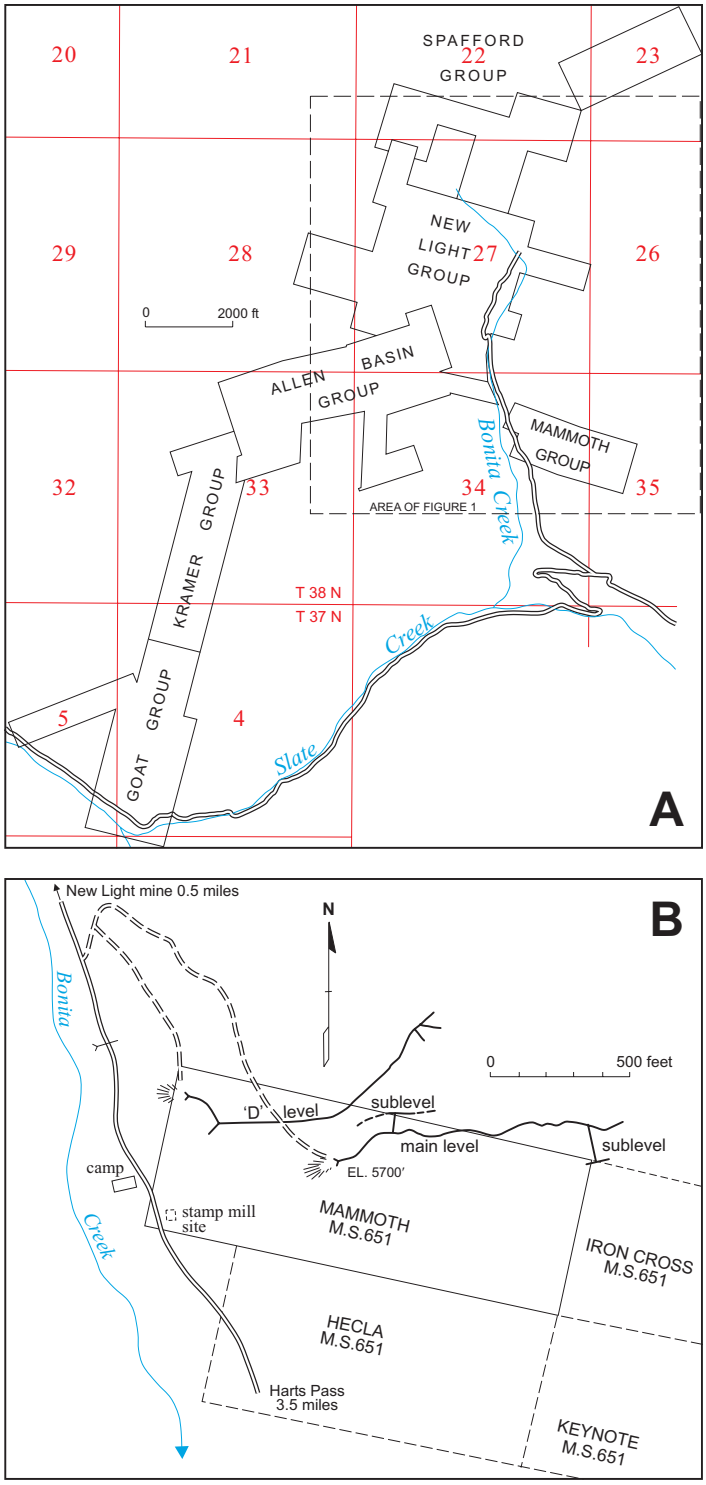

Figure 2. A. Map showing approximate location and areal relationship of claims in the Barron area. Dashed line shows approximate location of Figure 1. (Modified from a Western Gold Mining Co. map, circa 1970.) **B.** Approximate location of features at the Mammoth mine and related claims. (Modified from Moen, 1969. See Mineral Survey 651 for actuals.)

acquired a 25-year lease on the property in 1973 during a spike in the price of gold. No data concerning this agreement is available.

Geologic Setting

Rocks in the vicinity of the New Light mine are argillite, quartzite, conglomerate, and shale of the Early Cretaceous Harts Pass Formation (Stoffel and others, 1990). The ore is localized in quartz shear zones up to 5 feet wide and in a quartz-cemented breccia pipe approximately 200 feet by 100 feet wide and 3000 feet long. The breccia is offset by a major east-northeast-trending fault and several minor faults that cause considerable difficulty in tracing its continuity underground and on the surface. Contact metamorphism attributed to a diorite stock on the mine site recrystallized sandstones and shales to a hornfels-like material and played a role in formation of the breccia pipe. The breccia contains sharply angular fragments of quartzite and hornfels in the range of 1 to 4 inches long (Fig. 4). These fragments make up about 80 percent of the rock mass; the remainder is composed of quartz-cemented veinlets 0.5 to 1 inch thick (Cheney, 1971). The quartz cementation contains argentite, chalcopyrite, pyrite, galena, and free gold. The high arsenic content of the New Light mill tailings indicates the presence of arsenopyrite, although this mineral has not been previously reported at the site. Extensive sampling of the breccia by WGM gave an average gold content of 0.33 ounces per ton gold and average silver content of 0.137 ounces per ton. Assays of mill concentrates showed finely divided sooty grains of platinum in the range 0.005 to 2.60 ounces per ton (Moen, 1969).

Mineralization at the Mammoth mine is located in argillite, shale, and fine-grained feldspathic sandstone of the Harts Pass Formation. The mineral assemblage is similar and probably related to that at the New Light mine, but the breccia pipe does not crop out on the property. Ore is concentrated in a well-defined quartz fissure vein carrying auriferous sulfides and free gold. The vein ranges from 2 to 40 inches in thickness in the Mammoth tunnel. In at least two places, the vein is offset about 25 feet by cross-faults. Extensive sampling conducted in 1935 by C.E. Phoenix gave an average grade of 0.68 ounce per ton in gold and 1.21 ounce per ton in silver (Moen, 1969). The vein on the 'D' level is 2 to 20 inches wide. A grab sample taken by Moen (1969) assayed 0.05 ounce of gold and 0.25 ounce of silver per ton.

Figure 3. Overview of the New Light mine excavations. The glory hole and open pit are in the upper left near the ridge. View to the north.

Figure 4. Quartz-cemented breccia in the New Light open pit. Hammer for scale.

Openings

The New Light mine ultimately consisted of six horizontal adits; in descending order by elevation, they are: adit 1 (Fig. 5), adit 2, Aleen tunnel, Triangle tunnel, adit 3, and adit 4. When we did our field work August of 2001, all of the openings were caved at the entrance or a short distance inside. A glory hole (Fig. 6) with near-vertical walls and open pit (Fig. 7) were excavated in the brecciated zone at the mine's highest elevation near point 6835 (Pasayten Peak 7.5-minute quadrangle, USGS). The New Light mine is spread out over a considerable area. The best sources for specific information on the relationship between underground development, surface work, and the ore deposit itself are unpublished reports in the DGER mine file: Cheney (1971) and Magill (1969).

Development at the Mammoth mine consisted of a 'lower' level, the 'D' level, the Mammoth tunnel, and two associated sublevels. The lower level referred to in historic documents was north of the mine camp on Bonita Creek, a few feet below the access road. It never reached the vein. Moen reported the lower adit caved in 1969. The D level is ~120 feet above the road and drives 600+ feet to the vein intersection, which it followed for

75 feet. The 995-foot long Mammoth tunnel lies approximately 200 feet higher than the D level on the same southwest-facing slope. The D level tunnel is reported as stable and accessible, but the condition of the Mammoth tunnel is fundamentally unsafe with a bad cave-in about 90 feet from the face (Dale Tonseth, USFS (retired), oral commun., 2002). Most of the production came from stopes above the Mammoth tunnel along the vein's northeast strike. We did not visit the Mammoth tunnel or locate raises that appear on historic maps to have reached the surface. See Fig. 2B and Moen (1969).

Materials and Structures

None of the original mill or camp buildings were found intact at either property. In Fig. 8 , the New Light mill is shown as it stood in the summer of 1979. Some pipe, miscellaneous scrap steel, and timbers remain at the mill site, in addition to the 220-horsepower Atlas diesel engine used to generate electrical power (Fig. 9). The 187-kilovolt alternating current generator attached to the engine has been removed, along with the engine's radiator.

Figure 5. Adit 1 portal at the New Light mine. View to the northwest.

Water

Water emanating from mine openings was virtually nonexistent. No samples were taken. New Light adit 2 and Mammoth tunnel had discharges of less than 1 gallon per minute; pH readings were 6.0. Conductivity readings of 275 and 360 μS/cm respectively indicate the presence of dissolved sulfides as sulfate ion. Sampling upstream and downstream of the mine areas in Bonita Creek (Raforth and others, 2002) indicated little, if any, deleterious effect on water quality.

Milling Operations

Milling tests conducted by Western Gold Mining Co. (WGM) for the New Light ore indicated that significant improvements in costs could be realized if the coarse slate inclusions in the breccia were eliminated by continuous screening of the ball mill discharge, sending all +3 mesh (>0.2 inch) material to the dump. Further grinding the sulfide fraction to –20 mesh (<0.026 inch) as a coarse, but suitable flotation cell feed, resulted in 90.2 percent gold recovery. It appears from WGM flow sheets that the mill circuit included a mercury amalgamation barrel for recovery of free gold. The 1979 operation of the property by Lion Mines Ltd. was the first full-scale use of the mill after the aforementioned process improvements were incorporated. The cyanide circuit reported by Moen (1969) was not used however. Flotation concentrates were shipped to the Cominco Ltd. smelter at Trail, B.C., and free gold was sent to Vancouver, B.C. A grab sample taken from the tailings exceeded maximum levels listed in the Model Toxics Control Act (WAC 173-340-900, see Table 4) for arsenic (250X), copper (50X), lead (30X), and zinc (6X).

Little information is available on the Mammoth mills. Two were eventually built, both relying on stamp-mill liberation of ore-bearing minerals and free gold by simple crushing operations, tabling jigs, and amalgamation. Precious metal recovery by this technology has historically been approximately 65 percent (Moen, 1969).

Figure 6. New Light glory hole. View to the south.

Waste Rock Dumps

Waste rock dumps adjacent to adits at the New Light are typically less than 500 cubic yards. The open pit floor is a massive jumble of broken rock. The Mammoth 'D' tunnel dump is com-

posed of unmineralized quartzite shotrock. We did not examine the upper Mammoth tunnel dump.

GENERAL INFORMATION

Names: New Light (also known as Eureka, Bonita, Slate Creek, Monica and Western Gold) and Mammoth (Table 1)

MAS/MILS sequence number: 0530730077 (New Light); 0530730037 (Mammoth)

Access: Two-wheel-drive road to Harts Pass and Slate Creek road. Locked gate at turn-off from Slate Creek road. Jeep road to mine sites in Barron basin.

Status of mining activity: none

Claim status: Per the Mining Law of 1872, lode mining claims fall in two categories:

1. *Unpatented claims* require a minimum annual expenditure of $100 assessment work per claim. A $100 maintenance fee may be paid in lieu of performing assessment work. Unpatented claims are classified as *active* or c*losed*. *Active* denotes a valid, up-to-date claim. *Closed* denotes that the maintenance fee, assessment work, or other requirements have not been met, and that the claim is no longer valid. The following table contains information on active claims only.
2. *Patented claims* are owned in fee simple by the discoverer and their assigns. A mineral survey is performed as part of the patent application process, prior to the issuance of a patent. Some lode claims initially mined underground may at a later date turn into an open pit operation. If this occurs, a Surface Mining Permit is required, which contains certain

During WGM's tenure as owner of the New Light mine, the company held 19 contiguous unpatented claims known as the New Light group, which comprised all the lands mined by WGM as well as the mill site. At some time prior to 1969, the company acquired possessory title to the Allen Basin group (14 patented claims) and the Goat, Kramer, and Spafford groups, totalling 31 unpatented claims (Fig. 2A). All of the unpatented claims were closed as of November 2002 (BLM LR 2000 database). The Allen Basin group (Mineral Survey 807, February 1907) are: Nephew, Aunt, Equinox, Black Dwarf, Captain Jack, IXL, Solitaire, Harnessmaker Extension, Harnessmaker, Uncle, Queen City, Sister Grace, Maccabee, and Blue Hen (Whatcom County assessor, written comm., 2002).

The Mammoth mine (Fig. 2B) has five patented claims (Mineral Survey 651, August 1903): Mammoth, Iron Cross, Keynote, Hecla, and Gold Leaf. None of the Mammoth mine's historic 60 unpatented claims are active (BLM LR 2000 database, 2002).

Table 1. Mine statistics

Mine name	County	Mine location	Decimal longitude	Decimal latitude	1:24,000 map	1:100,000 map
New Light	Whatcom	sec.27, T38N R17E	120.725492	48.761381	Pasayten Peak	Robinson Mountain
Mammoth	Whatcom	NE¼ sec. 34 and NW¼ sec.35, T38N R17E	120.713781	48.753261	Pasayten Peak	Robinson Mountain.

Figure 7. New Light open pit excavation. View to the north.

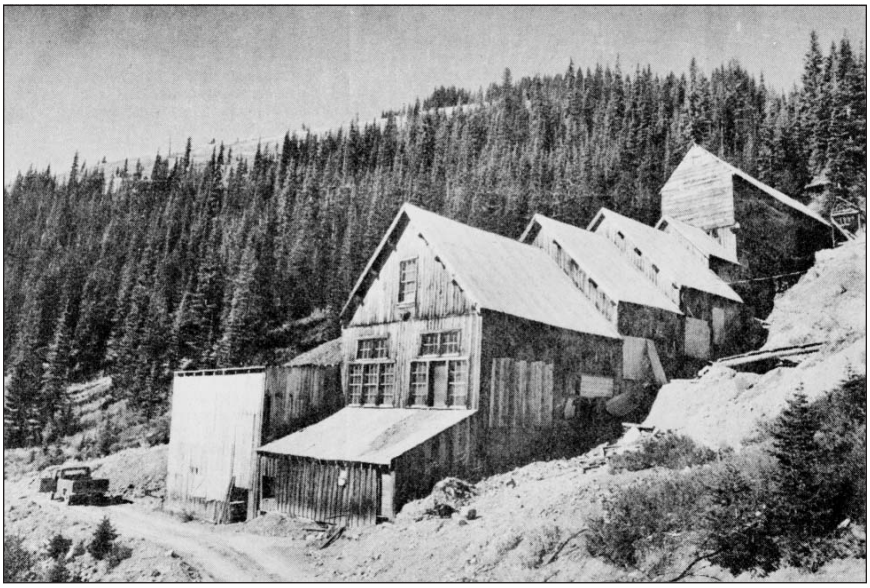

Figure 8. New Light mill circa 1979. View to the southwest; access road in foreground.

Current ownership of lands formerly mined:
Allen Basin group claims—North Cascades Exploration, Inc., Olympia, Wash.

Mammoth group claims—Alvin P. Earle, Jr., Blachly, Ore.

Surrounding land status:
Wenatchee–Okanogan National Forest (USFS)

Location and Map Information

Directions: The Slate Creek Mining District is approximately 16 miles west of Mazama. From Mazama on SR 20, proceed northwest past the Lost River Resort Airport to USFS road 5400, which climbs approximately 6 miles to Harts Pass. Proceed downgrade on Slate Creek Road approximately 2.4 miles to the intersection with a jeep road following Benson Creek northerly past a locked gate. A long rust-colored waste rock dump can be seen stretching downhill from the Mammoth tunnel adit on the east side of the access road, 0.8 miles past the gate (Fig. 10). The road passes through the New Light mill site at 1.2 miles (Fig. 11). From the mill site at elevation 5520 feet, a series of four switchbacks climb northwest past New Light adits 3, 2, and 1, ending at a glory hole and open pit at elevation 6600 feet.

Figure 9. 220-horsepower Atlas diesel engine at the New Light mill site.

Mine Operations Data

Type of mine: New Light—underground and open pit with mill; Mammoth mine—underground with mill

Commodities mined: The New Light mine's primary commodity was gold; minor amounts of silver, copper, nickel, platinum and lead were contained in the mineral assemblage. The primary commodity at the Mammoth mine was gold, with minor silver, lead, zinc and arsenic.

Geologic setting: Rocks in the vicinity of the New Light mine are mainly arkose, quartzite, conglomerate, argillite and slate of the Harts Pass Formation (Lower Cretaceous). A small diorite stock intrudes these sediments northwest of the mine. The gold-bearing horizon is limited to an extensive brecciated zone consisting of angular fragments of slate and argillite. Gold-bearing quartz is the main cementing agent. It contains small amounts of fine-grained pyrite, pyrrhotite, chalcopyrite and galena. Most of the gold content is microscopic native metal. The breccia has undergone post-deposition faulting causing considerable difficulty in mine layout and maintaining contact with ore (Cheney, 1971).

Figure 10. Mammoth mine waste rock dump (arrow). View to the east.

A gold-bearing quartz fissure vein at the Mammoth mine cross cuts bedding planes in slate, quartzite and arkose of the Harts Pass Formation. The vein strikes northeast and dips 45 to 60 degrees north. Its width varies from 2 to 40 inches.

Ore minerals: New Light—native gold, sylvanite, galena, chalcopyrite, native platinum; Mammoth—gold, sphalerite, galena

Non-ore minerals: quartz (SiO_2), calcite ($CaCO_3$), pyrite (FeS_2)

Host rock: slate, quartzite, arkose

Period of production: Mining at the New Light took place during sporadic periods of activity between 1895 and 1980. The Mammoth mine also began operations in 1895. For all practical purposes, the mine ceased production in 1905, excepting a small shipment made to the Tacoma smelter in 1942.

Development: New Light mine contained about 7200 feet of underground workings, two glory holes, and one open pit. Horizontal adits 1, 2, 3, and 4, the Aleen tunnel, and the Triangle tunnel were driven into the gold-bearing breccia. A rail tram enclosed by a snowshed transported ore down a steep slope from adit 1 to the flotation mill on Bonita Creek. Reports indicate that five levels were opened at the Mammoth mine, however almost all production tonnage came from stopes along the 995-foot long Mammoth tunnel between 1895 and 1905. A winze and a raise were driven at 235 feet and 900 feet respectively from the portal (Moen, 1969).

Table 2. Mine features. – – –, no data; *, data from DGER mine map file; **, numbered photos online at http://www.dnr.wa.gov/geology/iaml/03-13/

Description	Condition	Fenced (yes/no)	Length (feet)	Width (feet)	Height/depth (feet)	True bearing	Elev. (feet)	Decimal longitude	Decimal latitude	Digital photo**
New Light adit 1	open, partly caved	no	500*	4	5.5	N60W	6505	120.7263	48.7611	Fig. 5
New Light adit 2	portal timbers intact, caved inside	no	400*	4	5.5	W	6428	120.725	48.761476	DSCN2071
New Light adit 3, north portal	caved	no	1100*	– – –	– – –	N80W*	6019	120.7201	48.7615	DSCN2073
New Light adit 3, south portal	– – –	– – –	400*	– – –	– – –	N30W*	6025	– – –	– – –	– – –
New Light adit 4	caved		700*	– – –	– – –	N55W*	5557	– – –	– – –	– – –
New Light Aleen tunnel	– – –	– – –	80*	– – –	– – –	N20W*	6273	– – –	– – –	– – –
New Light Triangle tunnel	caved	no	100*	– – –	– – –	N45W*	6149	– – –	– – –	DSCN2069
New Light glory hole	open, walls vertical to 45 degree slopes	no	100	150	90	– – –	6679	120.7275	48.76171	DSCN2056, Fig. 6, DSCN2062
New Light open pit	open	no	200	200	150	– – –	6600	120.7271	48.76163	Fig. 7, DSCN2053
New Light mill site	burned, crushed	no	125	40	– – –	– – –	5350	120.7181	48.75924	DSCN2081, DSCN2083, Fig. 11
Mammoth tunnel, also mineral survey #651 monument #2	open	no	995*	8	10	S15E	5480	120.7154	48.75184	DSCN2089, DSCN2090, Fig. 10
Mammoth mill site	crushed	no	50	50	– – –	– – –	5250	120.7158	48.75215	DSCN2091

Production: The total dollar figure for the New Light mine between 1895 and 1949 was approximately $1,250,000. Tonnage or dollar value of production from open pit operations and other development since that time are unknown. Moen (1969) estimated $544,750 at the Mammoth mine based on production and mill recovery estimates from 15,000 tons.

Table 3. Soil analysis. Metal concentrations in milligrams per kilogram; numbers in parentheses indicate factor by which analysis exceeds standards shown in Table 4; – – –, no data

Sample location	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc	Gold
New Light mill site	4900 (250X)	– – –	5000 (50X)	390,000	6600 (30X)	– – –	2000 (6X)	– – –

Table 4. Model Toxics Cleanup Act, WAC 173-340-900. Table 749-2: Priority contaminants of ecological concern for sites that qualify for the simplified terrestrial ecological evaluation procedure (partial data). Concentrations are in milligrams per kilogram. Levels shown are for unrestricted land use. Levels for silver, gold, and iron are not specified

Metals	Arsenic III	Cadmium	Copper	Lead	Mercury	Zinc
mg/Kg	20	25	100	220	9	270

PHYSICAL ATTRIBUTES

Features: see Table 2

Materials: Several hundred feet of pipe are on the dump at New Light adit 2. At the mill site, we found two 55-gallon drums of unknown material and 10 pieces of about 8 inch x 10 inch x 14 foot timbers (Fig. 12). Mammoth had none.

Machinery: A 6-cylinder, 220-horsepower Atlas diesel still occupies its former foundation at the New Light mill site. An oil reservoir is attached. It originally powered a 187-kilovolt Westinghouse alternating current generator, which is no longer there.

Structures: The New Light mill building and wood-stave water tank have been destroyed by snow accumulation or slides. A concrete cistern below the mill still contains water. The 5-stamp mill erected below the Mammoth tunnel has collapsed and lies beneath rotting timbers. A recreation cabin has been erected at the mouth of the D level tunnel.

Presence of unstable slopes, walls, waste rock, tailings or impoundments: none

Analysis of tailings and dumps: see Tables 3 and 4

Waste rock, tailings, or dumps in excess of 500 cubic yards: at all sites

Reclamation activity: Natural vegetation has overtaken almost all the New Light mill tailings area. The mine dumps are barren.

VEGETATION

Most of the New Light mine workings are at or above timberline. Grasses and wildflowers occupy areas undisturbed by mining activity. The tailings disposal area downslope from the mill toward Bonita Creek supports unstressed grass, brush, cattails and wildflowers (gentian and pearly everlasting). Isolated stands of alpine fir, 12- to 18-inch diameter at base, grow on the slope.

WILDLIFE

See Table 5 for bat information. No samples were taken of benthic macroinvertebrates.

Table 5. Bat information.

Opening	Aspect	Air temp. at portal	Air flow: exhaust	Air flow: intake	Multiple openings	Bat evidence
Mammoth tunnel	W	– – –	yes	– – –	yes, unconfirmed	none
New Light adits	SE	– – –	no	– – –	– – –	none

WATER QUALITY

Surface waters observed: Bonita Creek crosses the former New Light access road twice, about a half mile east of the open pit and glory hole. It flows downstream through the New Light mill site, beneath the Mammoth tunnel and mill site, and discharges into Slate Creek one mile past the lowest mine workings.

Proximity to surface waters: 50 to 2600 feet

Domestic use: Bonita Creek is local water source for recreation users.

Acid mine drainage or staining: none

Water field data: see Tables 6 and 7

Surface water migration: Water discharging from all the openings examined infiltrate talus or waste rock within 50 yards of the portal.

Figure 11. Overview of New Light mill site. Revegetated tailings in the foreground terraces.

ACKNOWLEDGMENTS

The authors thank our editor Jari Roloff for the layout and helpful suggestions on content of this report. Robert Raforth provided additional water quality information collected in support of the Department of Ecology Water Quality Program.

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Table 6. Surface water field data. – – –, no data; *, data collected by Robert L. Raforth, Washington Department of Ecology, Water Quality Division; low flow, Aug. 2001; high flow, June 2001 (Raforth and others, 2002); **, numbered photos online at http://www.dnr.wa.gov/geology/iaml/03-13/

Sample ID	Description	Flow (gpm)	Conductivity (μS/cm)	pH	Bed color	Temp. (°F)	Elev. (feet)	Decimal longitude	Decimal latitude	Digital photo**
no sample	New Light adit 2	1	275	6	natural	– – –	6428	120.725	48.76147	DSCN2071
no sample	Bonita Creek	20	67	5	natural	– – –	6242	120.7188	48.76611	– – –
no sample	D tunnel at Mammoth mine	<1	360	6	natural	– – –	5480	120.7154	48.75184	DSCN2090
348068 348069	Bonita Creek upstream, low flow*	<1	56	6.8	natural	60	6250	See Fig. 1	See Fig. 1	– – –
– – –	Bonita Creek upstream, high flow*	3	29	7.9	natural	44	6250	See Fig. 1	See Fig. 1	– – –
348070 348071	Bonita Creek downstream, low flow*	5	77	6	natural	44	5350	See Fig. 1	See Fig. 1	– – –
– – –	Bonita Creek downstream, high flow*	60	52	7.9	natural	48	5350	See Fig. 1	See Fig. 1	– – –

Table 7. Surface water analysis. Metal concentrations are mg/L; Hardness is in mg/L. ≤ indicates metal was not detected; the number following is the practical quantitation limit above which results are accurate for the particular analysis method—the metal could be present in any concentration up to that limit and not be detected. – – –, no data. *, data collected by Robert L. Raforth, Washington Department of Ecology, Water Quality Division, low flow = Aug. 2001; high flow = June 2001 (Raforth and others, 2002). **, standards for these metals are hardness dependent. Conversion formulae are shown in http://www.ecy.wa.gov/pubs/wac173201a.pdf. Standards calculated for hardness values specific to Part 1 below, are shown in Appendix B

PART 1: ANALYSIS BY USEPA METHOD 6020, INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRY*

Sample location	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc	Hardness
Bonita Creek upstream, low flow*	7.15	≤0.02	0.85	≤20	≤0.02	≤0.002	0.52	24.4
Bonita Creek upstream, high flow*	9.29	≤0.02	0.50	≤23	≤0.02	0.0061	≤0.02	15.6
Bonita Creek, downstream, low flow*	6.00	≤0.02	0.51	≤20	≤0.02	≤0.002	0.95	36.0
Bonita Creek downstream, high flow*	7.42	≤0.02	0.38	≤20	≤0.02	0.0049	0.37	24.4

PART 2: APPLICABLE WASHINGTON STATE WATER QUALITY STANDARDS

Type of standards (applicable Washington Administrative Code)	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc	Hardness
Surface water standards (WAC 173-201A, Standard for aquatic life in surface freshwater, chronic level maximums at 100 mg/L hardness)	190	**	**	none	**	0.012	**	100
Ground water standards (WAC 246-290, Washington State Department of Health, standards for ground water, domestic consumption)	50.0	none	1300	300 (cosmetic only)	15	2.0	5000	– – –

Norman, D. K., 2000, Washington's inactive and abandoned metal mine inventory and database: Washington Geology, v. 28, no. 1/ 2, p. 16-18.

Raforth, R. L.; Norman, D. K.; Johnson, Art, 2002, Second screening investigation of water and sediment quality of creeks in ten Washington mining districts, with emphasis on metals: Washington Department of Ecology Publication 02-03-024, 126 p.

Stoffel, K. L.; McGroder, M. F., compilers, 1990, Geologic map of the Robinson Mtn. 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 90-5, 39 p., 1 plate. ■

Figure 12. Timbers and 55-gallon drums at New Light mill.

Appendix A

PHOTOGRAPHIC DOCUMENTATION

Photos (JPEG format) listed in tables may be found on our website at http://www.dnr.wa.gov/geology/iaml/03-13/.

METHODS

We recorded observations and measurements in the field. Longitude and latitude were recorded in NAD83 decimal degree format. Literature research provided data on underground development, which was verified in the field when possible.

All water samples were collected as simple grab samples in pre-cleaned 500 mL HDPE bottles with preservative and kept on ice for transport to Sound Analytical Services, Inc. (SAS). Soil samples from dumps or tailings were taken from subsurface material and double bagged in polyethylene. Chain of custody was maintained.

Water and soil samples were analyzed for arsenic, cadmium, copper, iron, lead, and zinc by inductively coupled plasma/mass spectrometry (ICP/MS) following USEPA Method 6010. Samples were analyzed for mercury by cold vapor atomic absorption (CVAA), USEPA Method 7470 (water), and Method 7471 (soil).

Holding times for the metals of interest were observed (28 days for mercury, 180 days for other metals). Instrument calibration was performed before each analytical run and checked by standards and blanks. Matrix spike and matrix spike duplicates were performed with each set.

FIELD EQUIPMENT

barometric altimeter
binoculars
digital camera
flashlight
Garmin GPS III+, handheld GPS unit
Hanna Instruments DiST WP-3 digital conductivity meter and calibration solution
litmus paper, range 0–14, and 4–7
Oakton digital pH meter
Oakton digital electrical conductivity meter
Taylor model 9841 digital thermometer

Appendix B

WATER QUALITY STANDARDS FOR HARDNESS DEPENDENT METALS

WAC 173-201A. Chronic standard (μg/l). Data collected by Robert L. Raforth, Washington Department of Ecology, Water Quality Division; low flow = Aug. 2001, high flow = June 2001 (Raforth and others, 2002)

Sample location	Hardness (mg/l)	Cd (μg/l)	Cu (μg/l)	Pb (μg/l)	Zn (μg/l)
Bonita Creek up low	24.4	0.36	3.4	0.53	32
Bonita Creek up high	15.6	0.26	2.3	0.32	22
Bonita Creek down low	36	0.48	4.7	0.81	44
Bonita Creek down high	24.4	0.36	3.4	0.53	32